Description and Synthesis of Spanish Sign Language Classifiers

Fernando López-Colino, Javier Garrido and José Colás

Human Computer Technology Laboratory, Escuela Politécnica Superior,
Universidad Autónoma de Madrid, Spain
[fj.lopez , javier.garrido, jose.colas]@uam.es

Abstract. This work presents the first approach to synthesize Spanish Sign Language (SpSL) *classifiers*, integrated into a SpSL synthesizer. Currently, all the efforts in automatic synthesis of SpSL just create the animation of a sequence of dictionary signs. This work includes the synthesis of the SpSL classification phenomena, which defines more complex elements than the dictionary signs, such as the *iconic classifiers*, and modifications to the representation of the dictionary signs, defined by the *introflexive classifiers* and the *affixal classifiers*.

Key words: Spanish Sign Language, Classifier Construction, Automatic Synthesis, Deaf People

1 Introduction

This work presents the first approach to describe and to synthesize Spanish Sign Language (SpSL) *classifiers* within the definition of a SpSL synthesizer [1]. Currently, all the efforts in automatic translation from Spanish to SpSL obtain a sequence of signs that should be synthesized. However, these approaches do not include the generation of the spatially and semantically complex structures called *classifiers* included in SpSL dialogs. *Classifiers* are a relevant part of Sign Languages (SL) which should be considered in the process of translation and synthesis. This work focuses on defining the way these elements are described and synthesized.

This paper is structured as follows: Section 2 reviews the current SpSL *classifiers* theory and defines the four kinds of *classifiers* defined for SpSL. Section 3 resumes the first approach to *classifiers* synthesis designed for American Sign Language. Section 4 presents our approach to the definition and synthesis of *classifiers* in SpSL and finally, Section 5 resumes this work.

2 Background

SpSL defines three main semantic units. This segregation is based on semantic and complexity properties.

- The first element is *fingerspelling*, an alphabet representation by means of signs. Each letter is represented using a hand shape and an orientation. Most letters are static one-handed signs but in some cases they require a simple animation.
- *Established signs* represent a concept. They have a well known and static meaning. Performance of these elements is more complex than fingerspelling. Describing *established signs* involves defining the seven basic sign parameters [2], sometimes for both hands in case of a double-handed sign.
- The last semantic unit of SL is *classifiers*. Different studies [3, 4, 5, 6, 7] proposed several approaches to the definition of this semantic unit in different SL. However, these approaches focus on the mimic capacities of the SL. Herrero Blanco [8] proposed a classification for this unit applied to SpSL, which focused on a morphological description of the alteration produced by the classification phenomena to the signed message and it is the approach we have used for this work.

2.1 Approach to SpSL Classifiers

Previous section has presented a classification of the signing units attending to semantics and complexity: *fingerspelling*, *established signs* and *classifiers*. The first two units have a static description and their synthesis is not modified by the semantic components of the message. On the other hand, *classifiers* unit requires a different approach for both translation and synthesis processes. This work only focuses on *classifiers* synthesis and the description of this semantic unit within the synthesizer input notation.

Herrero Blanco [8] presented a classification of *classifiers* in SpSL. This classification suggests four different kinds of *classifiers*, attending to a morphological description of this semantic unit and the way it is used in SpSL:

- The *classifier nouns* are *established signs* that are used as modifiers of the next sign. These signs can be used independently with their own meaning, but they can be also used, preceding another sign, to define a new concept. E.g. *established signs* AGUA (water) and POLEA (pulley) have their own meaning and are found independently of each other. However, the construction AGUA - POLEA as a sequence of two signs produces the meaning of "pozo" (well). Another example is the construction SÁBADO - DOMINGO (saturday - sunday), that means "fin de semana" (weekend).
- The *introflexive classifier* defines a modification to one of the seven basic parameters of a sign. The more often modified parameter is the Configuration parameter of the sign, but modifying the Orientation and Movement parameters is also a common practice. When the classification alters the Configuration parameter, a new hand shape is used instead of the original one. The new hand shape corresponds to the Configuration parameter of the classifier sign, whose meaning is added to the original classified sign. This feature only applies to pairs of classifier and classified signs whose meanings are related to spatial and tangible properties. For example, to express the

meaning of a fallen television, the signer will modify the Configuration parameter of the sign TELEVISIÓN (television) and will use the hand shape of the sign CAÍDO (fallen). But this *classifier* will not be used if the adjective expresses non spatial properties, e.g. TELEVISIÓN CARA (expensive television).
This kind of *classifier* implies modifications to the synthesis of the classified sign. They can be only established during translation, when the classifier and classified signs are defined.

- The *iconic classifiers* are a description that depicts the movement and location of the objects in the space. These productive units mimic reality so their definition must be obtained from the implicit or explicit description found in the natural language messages.
- The last kind of *classifiers* units is the *affixal classifier*. This unit merges the *introflexive classifier* and the *iconic classifiers*, because while the left hand is performing an *iconic classifier*, at the same time, the right hand performs an *established sign* whose Location and Plane parameters are modified. This modification results in an alteration of the performance of the sign in which the main direction of the sign is oriented to the left hand.
  This kind of *classifiers* can be observed in the construction "mirar una naranja" (to look at an orange): i) the sign NARANJA_FRUTO (orange as fruit) is performed normally, ii) the left hand establishes the spatial position of the orange, iii) the right hand performs the sign MIRAR (to look at) but the final position of the right hand is modified to be located near the left hand, which is the virtual position of the orange.

3 Related Work

Huenerfauth [9, 10] proposed the first approach to *classifiers* automatic synthesis. This approach used a software system to get a 3D scene described by means of natural language (English): AnimNL [11, 12, 13]. The information obtained from the AnimNL program was used as basis for the American Sign Language *classifiers* automatic synthesis. This program uses a library of Parametrized Action Representations (PARs) as templates to describe the scene and the actions of all the elements that populate that scene.

The work proposed in [9, 10] only provides a solution for *iconic classifiers* and does not for the others. Furthermore, there is not an equivalent software for Spanish that could be used as basis.

4 Description and Synthesis of SpSL Classifiers

This section describes how each of the four kinds of *classifiers* described in Section 2.1 is defined in the input notation, and how the synthesis process is modified in order to generate this semantic unit.

4.1 Input notation

Most SL synthesizers use standard symbolic notations as sign definition basis. Notations such as HamNoSys [14, 15] and SignWriting [16] are graphic representations of SL and have computer-friendly versions: SiGML [17] for the HamNoSys notation and SWML [18] for the SignWriting version. Gesture synthesis for these projects is a direct conversion from SWML or SiGML into VRML. Grieve-Smith [19] uses the Stokoe notation to define the signs, which is similar to the HamNoSys notation. There is also another representation system called Szczepankowski's gestographic notation [20] used in Polish Sign Language. This is a textual notation as it uses regular ASCII characters so it is computer friendly. However, it does not represent all of the sign parameters. All of these notations require considerable knowledge of the SL structure and learning in order to be used.

The HLSML (*High Level Signing Markup Language*) notation we have created, was designed with the following four objectives: i) Generate an XML-based notation which could be used by people with minimal SpSL knowledge. ii) Define the three different semantic units (*fingerspelling*, *established signs* and *classifiers*) in the same specification. iii) Allow the use of modifiers to change the representation of a sign. iv) Contemplate the parallel behavior of non-hand features and *affixal classifiers* in the signing process.

The definition of the three semantic units in the HLSML specification requires two different approaches, one for the dictionary sings (element <sign>) and *fingerspelling* (element <spell>) and another for the *classifiers*. *Established signs* are stored in a relational database, so HLSML only establishes a reference to the sign headword. The *fingerspelling* alphabet has been also stored in the relational database [21] using one static sign per letter, so HLSML defines a *fingerspelling* sequence using any Spanish word. These two semantic units allow the definition of SpSL messages without any knowledge of this sign language.

4.2 Description and Synthesis of *Classifier Nouns*

This kind of *classifiers* is composed by a sequence of two *established signs*: the first sign adds its meaning to the second one in order to create a new concept related to the meanings of the two signs. This kind of *classifiers* does not modify the synthesis process, because it is equivalent to a sequence of two independent *established signs* retrieved from the relational database. Fig. 1 shows the example proposed in Section 2.1 for the *classifier nouns*.

4.3 Description and Synthesis of *Introflexive Classifiers*

The *introflexive classifiers* imply a modification of the definition of one of the seven basic parameters of the modified sign. Therefore, describing an *introflexive classifier* requires defining the modified parameter and the new value for this parameter. This description is done using the element <signClassifier> whose "name" attribute defines the modified parameter and its descendant element

```
<!DOCTYPE hlsml SYSTEM
          "hlsml.dtd">
<hlsml>
 <sentence
       language='es'
       tag ='standard'>
  <sign name="AGUA" />
  <sign name="POLEA"/>
 </sentence>
</hlsml>
```

(a) HLSML definition.

(b) Sign AGUA (water)

(c) Sign POLEA (pulley)

Fig. 1. Example of a *classifier noun*, where the sign AGUA (water) and the sign POLEA (pulley) merge their meanings to create the concept "pozo" (well).

defines the new value. This new value can be defined directly using the name of the parameter's unit (e.g. "fist_01") or using the name of an *established sign*, and recovering the selected parameter from the classifier sign instead of from the classified one (Fig. 2).

```
<!DOCTYPE hlsml SYSTEM
          "hlsml.dtd">
<hlsml>
 <sentence
      language='es'
      tag ='standard'>
  <sign
    name="TELEVISION">
   <signClassifier
    name="configuration">
    <sign name ="CAIDO"/>
   </signClassifier >
  </sign>
 </sentence>
</hlsml>
```

(a) HLSML definition.

(b) Original sign

(c) Modified sign

Fig. 2. Example of an *introflexive classifier*, where the sign TELEVISIÓN (television) is modified by the sign CAIDO (fallen).

4.4 Description and Synthesis of *Iconic Classifiers*

Iconic classifiers are mimic descriptions of some information. These elements can be used to define the spatial positions, relations and movements of the

elements of a conversation. As their definition is based on semantic information obtained from natural language processing, there is no possibility of storing *iconic classifiers* final representation, so this kind of *classifiers* must be defined and generated dynamically.

This kind of *classifiers* has been defined as a sequence of basic units described by the element <classifier>. This basic unit describes statically the hands, non-hand elements (i.e. facial expressions and body postures) and head and eyes gazing direction.

Each hand requires defining three sign parameters (Configuration, Orientation and Contact Point parameters) and a 3D position. This 3D position is not defined using the Location and Plane parameters. It requires a spatial coordinate within the articulatory space (Fig. 3). Using these four elements, we define an *iconic classifier* unit which is similar to a static manual sign. *Iconic classifiers* may require that the avatar faces to or gazes at a defined position, which can be also defined within the classifier articulatory space or by referencing a part of the body.

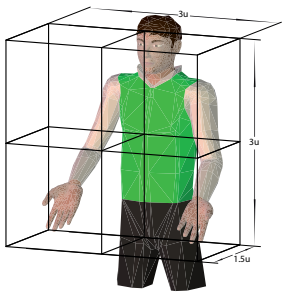

Fig. 3. The black wired box represents the classifier articulatory space. The coordinates within this articulatory space use the position of the chest as origin of coordinates and their definition is relative to the length of the avatar's upper arm. The value of u is the length of the avatar's upper arm.

Dynamic *iconic classifiers* require hand movement or gazing at different points. A sequence of static units with a time gap between them, defined by the <classifierTransition> item, will define the *iconic classifiers* animation. Fig. 4 shows an example of an *iconic classifier* representing a person walking along a linear path.

4.5 Description and Synthesis of *Affixal Classifiers*

The last kind of *classifiers* is the *affixal classifiers*. This kind of *classifiers* merges the definition of the *introflexive classifiers* and the *iconic classifiers*, so the description requires defining a parallel behavior of the different *classifiers* that are

required for the definition of these *affixal classifiers*. The element <compound> is used for defining a parallel behavior of its children elements.

In order to define a modification to the synthesis process of the modified sign, the <signClassifier> element uses the value "affixal" for the "name" attribute. The child element of <signClassifier> defines the directional objective that modifies the last part of the classified sign.

Fig. 5 shows an example of this kind of *classifiers* which shows the sentence "mirar una naranja" (look at an orange). The user signs the sign NARANJA_FRUTO (orange as fruit) as an *established sign* (Fig. 5(b)). Next, the user defines the position of that orange in the articulatory space (Fig. 5(c)). Finally, the user, instead of representing the sign MIRAR (look at) as a *established sign* (Fig. 5(e)), modifies the last part of the sign and directs the active hand and the head towards the position of the orange in the articulatory space (Fig. 5(d)).

5 Conclussions and Future Work

We have presented a novel and functional approach to the description and synthesis of *classifiers* in SpSL integrated into a SpSL synthesizer. This semantic unit is important for the communication between deaf people. Therefore, our SpSL automatic synthesizer will be able to create more humanlike signed messages. This work also presented how using HLSML, the notation described in this work, the description of this semantic unit is an easy and fast process.

However, future development will focus on the creation of a *classifiers* lexicon in order to make the definition of *classifiers*, specially *iconic classifiers*, even an easier process by defining a reference to the *classifiers* in the HLSML message instead of describing them.

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```
<!DOCTYPE hlsml SYSTEM "hlsml.dtd">
<hlsml>
<sentence language="es" tag="standard" >
<compound>
 <classifierSequence>
  <!-- Fig. 4(b) -->
  <classifier armDivision="7" time="700">
   <hand side="right">
    <configuration>
     <element name="config_006" />
    </configuration>
    <orientation>
     <element name="f_p_000_d" />
    </orientation>
    <coordinate width="-5" height="2"
                           depth="4" />
    <contactPoint>
     <element name="point_4" />
    </contactPoint>
   </hand>
   <headLookAt>
    <coordinate width="-5" height="0"
                           depth="4" />
   </headLookAt>
   <eyesLookAt>
    <coordinate width="-5" height="2"
                           depth="4" />
   </eyesLookAt>
  </classifier>
  <!-- Fig. 4(c) -->
  <classifierTransition time="400" />
  <!-- Fig. 4(d) -->
  <classifier armDivision="7" time="700">
   <hand side="right">
    <configuration>
     <element name="config_006" />
    </configuration>
    <orientation>
     <element name="f_p_000_d" />
    </orientation>
    <coordinate width="1" height="2"
                           depth="4" />
    <contactPoint>
     <element name="point_4" />
    </contactPoint>
   </hand>
   <headLookAt>
    <coordinate width="1" height="0"
                           depth="4" />
   </headLookAt>
   <eyesLookAt>
    <coordinate width="1" height="2"
                           depth="4" />
   </eyesLookAt>
  </classifier>
 </classifierSequence>
</compound></sentence></hlsml>
```

(a) HLSML definition.

(b) Initial Position

(c) Transition

(d) Final position

Fig. 4. Example of an *iconic classifier*, where the avatar describes the situation of a person walking along a linear path.

```
<!DOCTYPE hlsml SYSTEM "hlsml.dtd">
<hlsml>
<sentence language="es" tag="standard">
 <!-- Fig. 5(b) -->
 <sign name="NARANJA_FRUTO"/>
 <!-- Fig. 5(c) -->
 <classifierSequence>
  <classifier armDivision="3"
              time="700">
   <hand side="left">
    <configuration>
     <element name="config_078"/>
    </configuration>
    <orientation>
     <element id="91"/>
    </orientation>
    <coordinate width="2" height="1"
                depth="3"/>
    <contactPoint>
     <element name="med_4"/>
    </contactPoint></hand></classifier>
 </classifierSequence>
 <!-- Fig. 5(d) -->
 <compound>
  <classifierSequence>
   <classifier armDivision="3"
               time="700">
    <hand side="left">
     <configuration>
      <element name="config_078"/>
     </configuration>
     <orientation>
      <element id="91"/>
     </orientation>
     <coordinate width="2" height="1"
                 depth="3"/>
     <contactPoint>
      <element name="med_4"/>
     </contactPoint></hand></classifier>
  </classifierSequence>
  <sentence>
   <sign name="MIRAR">
    <signClassifier
     name="affixal">
     <element name="l_palm"/>
    </signClassifier></sign></sentence>
    </compound></sentence></hlsml>
```

(a) HLSML definition.

(b) Sign NARANJA

(c) Object position

(d) Modified MIRAR

(e) Orig. MIRAR

Fig. 5. Example of an *affixal classifier*, where the sign MIRAR (look at) is oriented towards the position of an orange in the articulatory space.